

TITLE OF THE INVENTION  
INFORMATION RECORDING APPARATUS AND METHOD, AND  
INFORMATION REPRODUCTION APPARATUS AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

5           This application is based upon and claims the  
benefit of priority from the prior Japanese Patent  
Application No. 2000-315511, filed October 16, 2000,  
the entire contents of which are incorporated herein by  
reference.

10                           BACKGROUND OF THE INVENTION

1. Field of the Invention

          The present invention relates to improvement of  
an information recording apparatus and method for  
recording information on a recording medium such as  
15   an optical disc or the like on/from which information  
can be written/read out. The present invention also  
relates to an information reproduction apparatus and  
method for reproducing information recorded on the  
recording medium.

20                           2. Description of the Related Art

          As is well known, recently, data rewritable  
optical discs have been developed and put into  
practical use. As data rewritable optical discs, for  
example, DVD (Digital Versatile Disc)-RAM (Random  
25   Access Memory), DVD-RW (Rewritable), and the like have  
prevailed.

          In a data rewritable optical disc, when the user

records, as digital data to be recorded, data as a long run of only one of two values, symmetry of RF (Radio Frequency) signals read upon reproduction is lost, thus adversely influencing various servo systems.

5           For this reason, digital data to be recorded undergoes a scramble process based on a scramble pattern generated by a pseudo random number generator or the like, so as to control one and the other values of data to have nearly equal frequencies of generation  
10           upon recording.

          On the other hand, in the DVD format, digital data to be recorded is segmented into predetermined reference units called sectors, and is recorded on an optical disc while assigning addresses for  
15           respective sectors. In this case, the scramble process for digital data to be recorded is done for each sector, and scramble patterns to be used are permanently determined for respective addresses.

          For this reason, in case of data such as  
20           management data, which is recorded at a predetermined location on an optical disc, is often changed only partially, and is rewritten entirely in a rewrite process, identical data undergoes a scramble process using an identical scramble pattern, and is  
25           repetitively recorded at an identical position on the optical disc.

          In this case, since the scramble process of

identical data using an identical scramble pattern  
always has an identical result, repetitively writing  
the scrambled data at an identical position on the  
optical disc consequently means to repetitively write  
5 identical data at an identical position on the optical  
disc.

However, when identical digital data is  
repetitively written at an identical position in  
response to every rewrite request like the management  
10 data, the rewrite life of the optical disc on which  
data is recorded using phase change marks may be  
impaired.

#### BRIEF SUMMARY OF THE INVENTION

The present invention has been made in  
15 consideration of the above situation, and has as its  
object to provide an information recording apparatus  
and method, which can minimize impairment of the  
rewrite life of a recording medium and can assure  
highly reliable data recording by preventing identical  
20 data from being repetitively written at an identical  
position.

It is another object of the present invention to  
provide an information reproduction apparatus and  
method which can attain highly reliable data  
25 reproduction from a recording medium on which data is  
recorded by the aforementioned information recording  
apparatus and method.

An information recording apparatus according to an embodiment of the present invention is directed to an information recording apparatus for scrambling digital data broken up into predetermined reference units, and recording the scrambled data on a recording medium.

The apparatus comprises a scramble processor scrambling digital data for each predetermined reference unit using a randomly generated scramble pattern, and a recording controller recording scramble pattern information for specifying the scramble pattern used in scrambling by the scramble processor on the recording medium.

An information recording method according to an embodiment of the present invention is directed to an information recording method for scrambling digital data broken up into predetermined reference units, and recording the scrambled data on a recording medium. The method comprises the scramble processing step of scrambling digital data for each predetermined reference unit using a randomly generated scramble pattern, and the recording control step of recording scramble pattern information for specifying the scramble pattern used in scrambling in the scramble processing step on the recording medium.

An information reproduction apparatus according to an embodiment of the present invention is directed to an information reproduction apparatus for reproducing

a recording medium on which digital data that have been broken up into predetermined reference units and have been scrambled respectively using randomly generated scramble patterns, and scramble pattern information for specifying the scramble pattern used to scramble each piece of digital data of the predetermined reference unit are recorded.

The apparatus comprises a descramble pattern generator generating a corresponding descramble pattern on the basis of the scramble pattern information read from the recording medium, and a descramble processor descrambling the digital data of the reference unit read from the recording medium on the basis of the descramble pattern generated by the descramble pattern generator.

An information reproduction method according to an embodiment of the present invention is directed to an information reproduction method for reproducing a recording medium on which digital data that have been broken up into predetermined reference units and have been scrambled respectively using randomly generated scramble patterns, and scramble pattern information for specifying the scramble pattern used to scramble each piece of digital data of the predetermined reference unit are recorded.

The method comprises the descramble pattern generation step of generating a corresponding

descramble pattern on the basis of the scramble pattern information read from the recording medium, and the descramble processing step of descrambling the digital data of the reference unit read from the recording medium on the basis of the descramble pattern generated in the descramble pattern generation step.

#### BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIG. 1 is a view for explaining the data format of digital data to be recorded per sector according to an embodiment of the present invention;

FIG. 2 is a chart for explaining the processing sequence for forming sectors of user data and converting them into physical data to be recorded in the embodiment of the present invention;

FIG. 3 is a block diagram for explaining an information recording apparatus for forming sectors of user data and converting them into physical data to be recorded in the embodiment of the present invention; and

FIG. 4 is a block diagram for explaining an information reproduction apparatus for reproducing a recording medium in the embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE INVENTION

An embodiment of the present invention will be described in detail hereinafter with reference to the accompanying drawings. FIG. 1 shows the data format

for one sector. Digital data to be recorded is broken up into sectors each having the structure shown in FIG. 1, undergoes a scramble process for respective sectors, and is recorded on a recording medium such as an optical disc.

One sector consists of  $172 \text{ bytes} \times 12 \text{ rows} = 2064 \text{ bytes}$ , and contains 4-byte identification data ID, a 2-byte ID error detection code IED, a 5-byte reserve field RSV, 1-byte scramble pattern data SP indicating a scramble pattern used, 2,048-byte user data, and a 4-byte error detection code EDC.

FIG. 2 shows the processing sequence for forming sectors from digital data to be recorded, and converting them into physical data to be recorded on a recording medium. After identification data ID, ID error detection code IED, a reserve field RSV, and scramble pattern data SP are appended to 2048-byte user data (steps A1, A2, and A3), an error detection code EDC for the user data is generated and appended to form a sector before a user data scramble process (step A4).

After that, the user data undergoes a scramble process using a scramble pattern designated by the scramble pattern SP to obtain a scrambled sector (step A5). A cross Reed-Solomon error correction code ECC is generated and appended for 16 scrambled sectors (step A6).

Recording sectors are those after the ECC is

appended, and error correction codes PI and PO are also  
appended (step A7). Physical sectors are data after  
sync codes (SYNC codes) are appended at the heads of  
every 91 bytes of the recording sectors, and 8-16  
5 modulation is executed (step A8).

FIG. 3 shows an information recording apparatus  
for forming sectors from digital data to be recorded,  
and converting them into physical data to be recorded  
on a recording medium. User data is broken up into  
10 sectors, and is supplied to a scramble processing  
circuit 11.

The scramble processing circuit 11 scrambles user  
data of the input sector on the basis of a scramble  
pattern output from a scramble pattern generation  
15 circuit 13 in accordance with an instruction from  
a scramble pattern selection circuit 12, and stores the  
scrambled data in its internal buffer 11a.

The scrambled user data output from the scramble  
processing circuit 11 is supplied to an appending  
20 circuit 14, and is appended with additional information  
such as identification data ID, an ID error detection  
code IED, reserve field RSV, scramble pattern data SP,  
an error detection code EDC, address data indicating  
the logical address of data, and the like.

25 In this case, the scramble pattern data SP is  
information that specifies the scramble pattern  
the scramble pattern selection circuit 12 makes



the scramble pattern generation circuit 13 output,  
and is supplied from the scramble pattern selection  
circuit 12.

After that, the sector data output from the  
5 appending circuit 14 is supplied to an error correction  
code appending circuit 15, and is appended with an ECC  
code. The sector data to which the ECC code is  
appended by the error correction code appending circuit  
15 is supplied to a data modulation circuit 16,  
10 undergoes 8-16 modulation, and is then recorded on a  
recording medium M such as an optical disc or the like.

In this case, the scramble pattern selection  
circuit 12 controls the scramble pattern generation  
circuit 13 to randomly change a scramble pattern even  
15 for a sector to be recorded at an identical position,  
i.e., an identical address on the recording medium M  
every write.

For this reason, even when identical data is  
repetitively recorded at an identical position on the  
20 recording medium M, since the scramble pattern randomly  
changes every recording, different physical data is  
recorded on the recording medium M in practice. In  
this manner, identical data can be prevented from being  
repetitively written at an identical position, and the  
25 rewrite life of the recording medium M is prolonged,  
thus assuring highly reliable data recording.

FIG. 4 shows an information reproduction apparatus

for reproducing the recording medium M on which data is recorded as described above. Reproduction data read from the recording medium M is supplied to a data demodulation circuit 17, undergoes 16-8 demodulation, and then undergoes error correction using the ECC code by an error correction circuit 18.

After that, data of a reference unit (for each sector) that has undergone error correction is supplied to a decoding circuit 19 to decode the identification data ID, ID error detection code IED, reserve field RSV, scramble pattern data SP, and error detection code EDC as well as user data.

Of these data, the user data output from the decoding circuit 19 is supplied to a descramble processing circuit 20, and is descrambled. In this case, the scramble pattern data SP decoded by the decoding circuit 19 is supplied to a descramble pattern selection circuit 21.

The descramble pattern selection circuit 21 controls a descramble pattern generation circuit 22 to generate a required descramble pattern on the basis of the input scramble pattern data SP. The descramble processing circuit 20 descrambles the input user data on the basis of the descramble pattern output from the descramble pattern generation circuit 22, and outputs the descrambled data as user data.

That is, a descramble pattern required for

the descramble process is generated on the basis of the  
scramble pattern data SP read from the recording medium  
M to descramble data read from the recording medium M.  
Hence, even when the scramble pattern randomly changes  
5 every recording, original user data can be accurately  
descrambled, thus allowing highly reliable data  
reproduction.

In the above embodiment, only the user data is  
scrambled. However, the present invention is not  
10 limited to this. For example, the identification data  
ID, ID error detection code IED, reserve field RSV,  
scramble pattern data SP, error detection code EDC, and  
the like may be scrambled simultaneously or  
individually, thus obtaining the same effect.